



A STATISTICAL APPROACH TO EVALUATE THE EFFECTS OF OBESITY ON HEALTH-CARE EXPENDITURE

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Abstract: *The problem of studying the causes of obesity is largely discussed in the literature by experts in nutrition and related diseases and is of particular interest in most recent years among scholars of business disciplines, especially as regards the impact on socio-health costs. After an overview of the geographical differences of obesity, related not only to eating habits, but also to lifestyles as well as hereditary factors, the purpose of this paper is try to trace the main functional relationships between BMI and health-care costs through the use of Multiple Correspondence Analysis and Partial Least Squares Regression.*

Keywords: *Obesity, food safety, health-care expenditure, social costs.*

1. Introduction

Worldwide obesity has more than doubled since 1980 when only 1 in every 10 people was obese. In 2008, 1.5 billion adults aged 20 and older, were overweight and of these over 200 million were men and nearly 300 million women [1]. In 2010 [21] nearly 43 million children under the age of five were overweight. However, an OECD forecast [14] shows that in the following decades overweight and obesity will increase steadily also in countries where prevalence of overweight is currently lower. Prevalence of overweight is more pronounced among men than women. This highlights a lot of regional differences with figures ranging -in both sexes- from nearly 80% in USA, where socio-economic costs amount to 103 billion euros, that is 1% of its GDP, to just 30% among males and 16% among females in Japan [2]. In most European countries, over 50% of males and over 40% of females are overbalanced.

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The rising obesity has caused a major public health problem worldwide with a significant economic and social impact as the direct costs of treating obesity appears to have greatly outweighed those of treating its secondary medical consequences.

2. Relationships between food behavior and disease: the role of food safety

Several economic studies have estimated the effects of obesity on health-care expenditure and social costs. Since 1990s an increased attention towards the relationship between nutrition and health/wellness has increasingly oriented consumers towards socially conscious and responsible purchase decisions and behaviour. In particular, over recent years and thanks to more available information, consumers' awareness of the links between production of goods and their social costs -if any- has increased thus favoring a substantial change in consumers' consumption behavior.

In fact, consumers have shown fairly high levels of awareness of the relationships between nutrition styles and related diseases, such as heart disease, cholesterol and diabetes [11]. In general, consumers are aware of the health problems associated with unhealthy food styles. Empirical studies have demonstrated that during 1990s, 71% of consumers were aware of the health problems associated with the amount of fat taken in by an individual whilst 59% of them were aware of the health/saturated fat intake [3]. Since 1990s consumers have given increasingly important to the diet/health relationship. In this way, the concept of food safety, even in the theoretical debate, is more bound to quality of life. As a result, food safety, not only means genuine and quality foods but also functional products that help prevent health risks. In fact, the knowledge on food safety in terms of nutritional/functional products can be twofold: knowledge of the principles (i.e., information on the percentage of calories that should come from fat) and knowledge of the specific nutrient content of a type of food (i.e. the percentage of vitamins, etc) [10] [17].

In this light, the demands for safety, quality, eco-sustainability, local specialty/identity and ethics upon the products are perceived both as intrinsic factors (such as taste, healthiness and look of products) and extrinsic factors (origin, quality labels and brands) including attractive factors (such as convenience – ratio between expected quality/price, service – preservability and user friendliness) [7].

However, in recent years, food consumption patterns are changing remarkably even in countries with traditionally high levels of obesity as an increased number of people is becoming more aware of, socially responsible for and oriented towards functional products. This is the result of a tighter connection between nutrition and health/wellness, which has a direct impact on the reduction of social costs related to the phenomena of food (un)safety.

3. Materials and Methods

Data have been collected from the multipurpose Italian survey “Aspetti della vita quotidiana” which was conducted by Italian Institute of Statistics (ISTAT) in 2009. The variables are weight and height (body mass index –BMI-), the ones that overlook socio-demographic characteristics (gender, age, civil status, education, occupation, residence), life habits (physical activity, diet,

smoking, handicaps, watching TV and sport events, etc.), satisfaction (monetary, job, health, family, friends, hobbies) and pathologies (diabetes, high blood pressure, respiratory and nervous system diseases, chronic pathologies, etc.).

The variables considered have been grouped into several blocks taking into account their different meaning and nature. In the following figures, we consider the variables blocks (Figure 1) and the relational model (Figure 2) which has been included in the analysis.

Bio-Data Variables Age (Classes) Gender Civil Status Educational Qualification Occupation Region	Lifestyle Variables Sport Activity TV watch (hours) Cinema (times/year) Sport Event Cigarettes (nr/day) Relation with friends Handicap	Pathology Variables Diabet High blood pressure Cronic Bronchitis Respiratory Failure Bronchial Asma Arthrosis Nerve Disturbe Chronic Pathology
Diet Variables Red Meet Cheese Fish food Vegetables Fruits Snack s Sweets Breakfast	Satisfaction Variables Economical Satisfaction Health Satisfaction Familiar Network Satisfaction Friend Network Satisfaction Hobbies Satisfaction Job Satisfaction Health Status Perception	Obesity Variables BMI Weight Tipology
		Health-care Costs Regional Helath Costs

Figure 1. Variables included in the blocks.

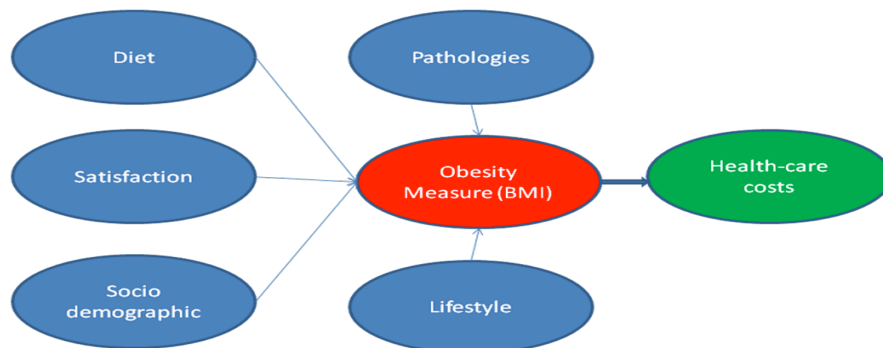


Figure 2. The relational model.

In order to estimate the relationships between individual characteristics and BMI and the repercussions on health-care costs, the following strategy has been adopted:

- *Step 1: quantification of the qualitative variables through Multiple Correspondence Analysis [9] [6]. MCA scales all variables and the coordinates on the factorial axes can be considered as a quantification on ordinal scale of the original qualitative variables.*
- *Step 2: Partial least regression among the BMI index (response variables) and the predictors (scaled variables obtained at the step 1).*

A classical statistical problem is to estimate the linear relationship between two sets of variables, $\mathbf{X}_{n,p}$ (explicative variables) and $\mathbf{Y}_{n,1}$ (dependent variable) where n is the number of statistical units and q the number of the explanatory variables. The technique which is largely used to

solve this problem is the multivariate regression model $Y = A + XB + E$ where $A(n, q)$ is the intercept term, $B(p, q)$ the gradient and $E(n, q)$ the error term. When there is a strong correlation among the predictors (quasi-collinearity), the regression coefficients obtained through the least squared methods are unstable and therefore the classical least squares regression model cannot be applied [5] [15]. The solution for overcoming this problem is offered by Partial Least Squares (PLS) Regression [16] [20].

In this step it's obtained the incidence (weight) of each explicative variables on the BMI.

Step 3: Simple Linear Regression between health-care cost (dependent variable) and BMI (predictor variable). In this step, it's estimated the incidence (weight) of the BMI on the health-care costs.

From theoretical point of view, other statistical techniques can be considered to quantify de data from ordinal to interval scale; several authors consider Rasch Analysis or Spline transformation for this purpose. A very nice discussion on this topic can be found in a recent study [4].

4. Results

In Italy more than 22 million people are overweight (BMI>25) and about 5 million people are obese (BMI>30). Like elsewhere overweight and obesity involve more men than women (55% versus 35%) even if focusing only on obesity the gender gap decrease: in fact, regarding II level obesity (BMI between 30 and 34,99) the percentage of men is quite 10% and that of women 7%; III level obesity (BMI>35) indeed involve more females than males (1.45% versus 1.94%). According relative risks estimate every woman overweighed or obese there are respectively almost 3 or more than 2 men. The share of overbalanced people decreases from Southern to Northern Italy where people have a risk of being overbalanced 30% lower. The geographical gaps are more evident for severe obesity especially for females whose percentage exceed 2% almost everywhere in Southern Italy. The percentages of overbalanced people increase with age and among 45-64yrs and 65yrs and over are respectively about three and five times that of 18-24yrs. Among socio-demographic characteristic the highest positive influence on the BMI indicator is reported by the modalities "Widowed" for the "Civil Status" variable ($\beta=1,423$) and "Illiterate" for qualification variable ($\beta=1,598$). Having at most primary education degree increases three times the risk of being obese compared to those with at least tertiary level. Obviously continuative and occasional sport practice ($\beta=-0,712$) reduce the prevalence of being overbalanced. Those who claims to meet their fiends everyday are less overweight and obese ($\beta=-1,446$) as soon as who goes to the cinema at least more than 1 time/month ($\beta=-0,789$). Eating habits, specifically concerning how many days a week eats pasta, bread or rice indicate that among people who never eat carbohydrates there are more obese than the other group ($\beta=0,417$) as soon as having an inadequate breakfast ($\beta=0,216$). The presence of severe handicap is strongly related to high BMI values ($\beta=1,844$) as well as presence of diabetes ($\beta=1,688$), high blood pressure ($\beta=1,118$), respiratory failure ($\beta=1,739$), bronchial asthma ($\beta=1,343$) and nervous system disease ($\beta=1,46$). Being low satisfied concerning the health status ($\beta=2,056$), the economic situation ($\beta=0,331$), the familiar ($\beta=0,81$) and friend network ($\beta=1,679$) and leisure ($\beta=0,804$) increases BMI values.

In the step three of the model we compute the strength of relationship between BMI and the regional health-care costs. The data show an incidence of 6% of the BMI on the regional costs related to the health services.

5. Discussion

The well known relationships in literature between socio-demographic characteristics, life habits, health status, network and the prevalence of overweight/obesity are confirmed. Albeit overweight involve more men than women, the gender gap reduces for 1st level obesity and amongst 2nd level obesity people involve more often women. In general, overweight and obesity increase as people age until a peak is reached and then they decline. Education is another important determinant of overweight and obesity: as expected, having a high level of education reduces the probability of a high BMI. Little or no social relationship and friendship affect overweight, more frequent, for example, among people don't go to cinema and don't attend, or haven't, friends. Moreover being satisfied of own economic status, health, familiar and friend network, use of leisure reduces the probability of overweight. Regarding diet habits it's important to note that food intake measures in terms of consumption of vegetables and fruit, sweets and snacks, etc, have no direct effects on BMI values even if international medical literature stress on influence of excess food-intake on overweight and obesity. On the other hand it's well known that differences between overweight and normal weight people are not in terms of frequency - time per die - but above all in terms of quantity - grams per die - of food consumption, impossible to measure though data used in this case. Then including dietary habits in these models is not statistical significant because of higher effect of other more significant variables. As emerges in other studies, when social environment is controlled for, the effect of eating habits might be are wiped out. Moreover some researches highlight that the Mediterranean Diet, prevalent in Italy, could protect *a priori* from overweight and obesity. Type of breakfast, indeed, is significant because this variable is above all a proxy variable of correct or incorrect dietary habits and also life-style.

Overweight and obesity in Italy increase moving from Northern to Southern regions with an incidence of 6% on regional health-care cost. Those findings are consistent with other research performed in Italy according to which obesity could impact about 8-9% of total social costs including healthcare costs and social cost - absence from work, lost productivity, disability support, early pension payments and increased demand on community resources. Approximately 140.000 hospitalizations per year are attributable to obesity and overeating disorders, both as principal diagnosis both as secondary diagnoses, with an average stay of about 9 days and a total number of days of hospitalization that exceeds one million units [13]. Also in some other European countries and North America obesity-related ill-health is absorbing between 6% and 10% of total health service budgets [21]. However a review of recent European studies on economic cost of obesity [19] focus on difficulties in identifying uniform criteria to estimate direct and indirect costs very different from country to country and ranging from 0.09% to 0.61% of total annual gross domestic income in Western European countries.

Despite overweight and obesity today affect, among adults, less people than in other European countries, according WHO and ISS [8] estimates one of the highest incidence of overweight individuals potentially at risk such as children and adolescents emerge. One 8-9 years old every

three are overbalanced as soon as one 11-15yrs every four with striking differences between North and South in this case too. This implies higher and higher cost of obesity for the future given that, as recently estimated [18] with a life expectancy of 75 years, an eighteen obese have an additional cost compared to a normal weight in order of about 100.000 euros.

To conclude, the social costs of obesity represent one of the more disturbing effects of this phenomenon, with implications of various types. The above findings indicate that further methodological research is called for in order to define guidelines for decision makers and practitioners, moving from a business/social approach to territorial approach. In this way, is possible to analyze as the local level (community with specific habits, lifestyles, education, social environment) may have different impacts on food habits of the citizens-consumers in order of food safety.

References

- [1]. Buckland, G., Bach, A., Serra-Majem, L. (2008). Obesity and the Mediterranean diet: a systematic review of observational and intervention studies. *Obesity review*, 9, 582-93.
- [2]. Costa Font, J., Fabbri, D., Gil, J. (2010). Decomposing cross-country differences in levels of obesity and overweight: Does the social environment matter? *Social Science & Medicine*, 70, 1185-93.
- [3]. Food Surveys Research Group (1996). *1994 Results from the Continuing Survey of Food Intakes by Individuals and the Diet and Health Knowledge Survey*. US Department of Agriculture, Agricultural Research Service, Beltsville, MD.
- [4]. Gallo, M. (2007). The scaling problems in service quality evaluation. *METODOLOGSKI ZVEZKI*, 2, 165-176.
- [5]. Gifi, A. (1990). *Non linear multivariate analysis*. Chichester: Wiley.
- [6]. Greenacre, M. J. (1984). *Theory and Application of Correspondence Analysis*. London: Academic Press.
- [7]. Grunert, K.G. (2005). Food quality and safety: consumer perception and demand. *European Review of Agricultural Economics*, 32, 369-391.
- [8]. Lamberti, A., Baglio, G., Nardone, P. (2010). Il problema dell'obesità infantile e dei fattori di rischio comportamentali. *Okkio alla SALUTE*. Risultati 2010 Centro Nazionale di Epidemiologia, Sorveglianza e Promozione della Salute - CNESPS Istituto Superiore di Sanità.
- [9]. Lebart, L., Morineau, A., and Warwick, K.M. (1984). *Multivariate Descriptive Statistical Analysis: Correspondence Analysis and Related Techniques for Large Matrices*, New York: John Wiley & Sons, Inc.
- [10]. Levy, A.S., Fein, S.B., Stephenson, M. (1993). Nutrition knowledge levels about dietary fats and cholesterol. *Journal of Nutrition Education*, 25, 60-66.
- [11]. Levy, A. S. and Heimbach, J.T. (1989). *Recent public education efforts about health and diet*. Food and Drug Administration, Center for Food Safety and Applied Nutrition, Washington, DC.
- [12]. Lobstein, T. (2010). Prevalence and costs of obesity. *Medicine*, 39 (1), 11-3.
- [13]. Masocco, M. (2011). *L'obesità dalle schede di dimissione ospedaliera*, Cnesps-Iss.
- [14]. Sassi, F. (2010). *Obesity and the Economics of Prevention*. Fit not Fat, OECD.

- [15]. Simonetti, B., Mahdi, S., Camminatiello, I. (2008). Robust PLS regression based on simple least median squares regression. In *Metodi, Modelli e Tecnologie dell'informazione a Supporto delle Decisioni*, vol. I Metodologie, eds. D'Ambra, L., Rostirolla, P., Squillante, M., Milano: Franco Angeli, 319-26.
- [16]. Tenenhaus, M., and Young, F.W. (1985). An analysis and synthesis of multiple correspondence analysis, optimal scaling, dual scaling, homogeneity analysis and other methods for quantifying categorical multivariate data. *Psychometrika*, 50, 91-119.
- [17]. Tippet, K.S., Mickle, S.J., Goldman, J.D., Sykes, K.E., Cook, D.A., Sebastian, R.S., Wilson, J.W., Smith, J. (1995). *Nationwide Food Surveys Report: 91-2. Food and Nutrient Intakes by Individuals in the United States. 1 Day, 1989-91*. Agricultural Research Service, US Department of Agriculture, Beltsville, MD.
- [18]. Turchetti, G. (2009). *L'obesità? Un "peso" sociale. I dati in uno studio della Scuola Superiore Sant'Anna di Pisa*. <http://www.sssup.it>
- [19]. von Lengerke, T., Krauth, C. (2011). Economic costs of adult obesity: A review of recent European studies with a focus on subgroup-specific costs. *Maturitas*, 69, 220-9.
- [20]. World, H. (1975). *Soft Modelling by Latent Variables: the Non-linear Iterative Partial Least Squares Approach*. In *Perspectives in Probability and Statistics: Papers in Honour of M.S Barlett on the occasion of his sixty-fifth birthday* , eds Gani, J.M., London: Academic Press.
- [21]. World Health Organisation – WHO (2012). Obesity and overweight. *Fact sheet*,311.